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1989 REPORT ON BRIDGE DECK WATERPROOFING

MATERIALS INFORMATION

ENGINEERING MATERIALS OFFICE

1989

REPORT ON

BRIDGE DECK

WATERPROOFING

BY

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1 INTRODUCTION

1.1 Acceptance Criteria

Bridge deck waterproofing is accepted under an "end result specification" (ERS). This ERS provides for a price reduction or rejection for work which fails to meet specified requirements for material thickness and quality. The thickness component of this ERS was first implemented in 1986 after a three year interim acceptance system which introduced the principles of ERS. The quality component was added in contracts awarded after September 1987.

1.2 Material Thickness

For 1989, the Bituminous Section of the Engineering Materials Office received 189 waterproofing thickness reports from across the Province, representing 65,051 m^2 of waterproofing. Each report was checked for completeness and accuracy and the data then entered on a micro computer spreadsheet. The micro computer was used to sort, analyze and graphically depict the accumulated data.

1.3 Material Quality

The Concrete Section of the Engineering Materials Office tested 171 samples of hot applied, rubberized asphalt waterproofing membrane in 1989. These samples represent products from four manufacturers and were submitted from contract job sites. The samples were obtained from the contractor's melting kettle, by the contractor at a time determined by the inspector, so as to be representative of material placed on the bridge deck.

Many of the samples received were substantially less than the four litres required which can preclude re-testing of a failed sample if requested by a contractor. The "Concrete Products Field Sample Sheets" accompanying the samples were frequently missing all the required documentation as described in the "Field Guide For Acceptance Of Bituminous Materials". In fact, one of the 172 samples received was not tested because of insufficient identification.

The samples were tested for compliance with six specification requirements:

1. Cone Penetration	@ 25°C	max.	110	(0.1 mm)
2. Cone Penetration	@ 50°C	max.	160	(0.1 mm)
3. Flow	@ 60°C	max.	3	(mm)
4. Low Temperature Flexibility	@ -25°C		Pass	
5. Toughness		min.	5.5	(Joules)
6. Toughness/Peak Load Ratio		min.	0.040	

The test results were entered on a micro computer spread sheet program.

2 DATA ANALYSIS

2.1 Material Thickness

Of the 189 lots reported, 5 were borderline and 1 was rejectable. (Refer to Provincial Highways report EM-79 for acceptance criteria.) The one rejectable lot was totally removed and reconstructed. After reconstruction the lot was acceptable and received full payment in respect of thickness.

The average thickness and standard deviation of membrane has remained the same over the last three construction seasons. The average thickness is very close to the target of 5 mm and the standard deviation reflects acceptable process control. Table 1 depicts the thickness statistics from 1984 to 1989.

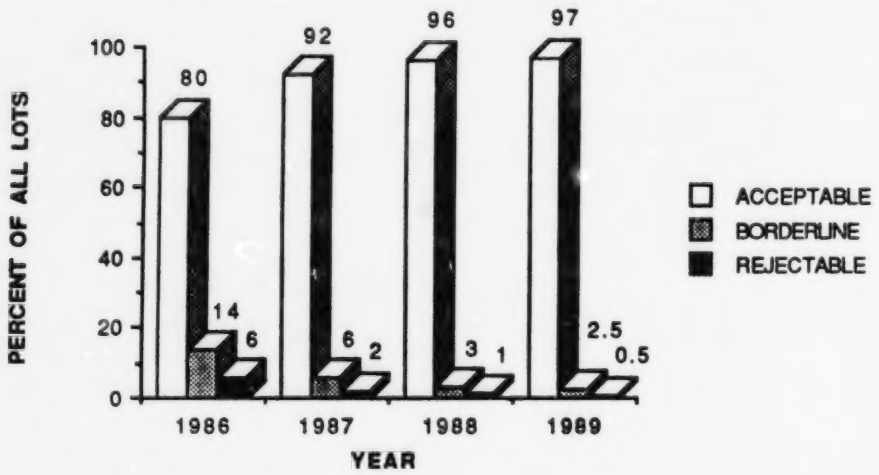
TABLE 1: ANNUAL MEMBRANE THICKNESS SUMMARY

YEAR	NO. OF LOTS	MEAN THICK. (mm)	AVG. LOT ST. DEV.
1984	261	4.7	0.75
1985	306	4.8	-
1986	157	4.9	0.70
1987	254	4.9	0.63
1988	319	4.9	0.63
1989	189	4.9	0.63

The larger number of lots for 1985 and 1988 are due to the waterproofing of the new and rehabilitated Burlington Bay Skyway bridges respectively, each of which had 75 lots.

In 1986, only 80% of all lots constructed were acceptable, improving to 97% in 1989. The one rejectable lot in 1989 became acceptable after reconstruction resulting in only 5 lots that did not receive full payment. Figure 1 depicts the yearly achievement.

FIG. 1: ANNUAL THICKNESS COMPLIANCE



Ten waterproofing contractors shared the work in 1989. Figure 2 demonstrates how the work was divided between the contractors. Of the ten contractors, five had all lots accepted at full price, four had some borderline and one had a rejectable lot. Figure 3 depicts the relative performance of each contractor (identities concealed).

Individual contractors' statistics are presented in the appendix.

FIG. 2: CONTRACTOR'S SHARE OF WORK

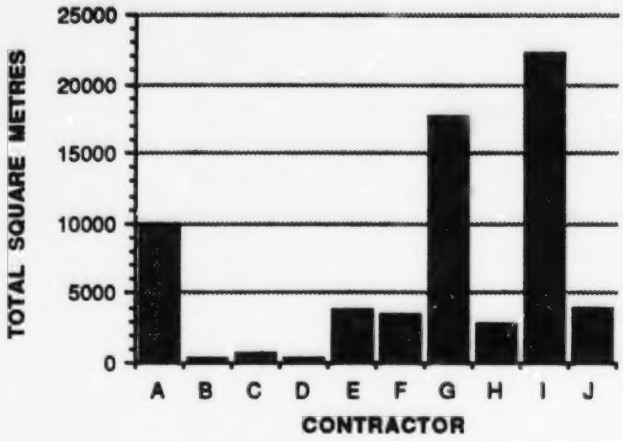
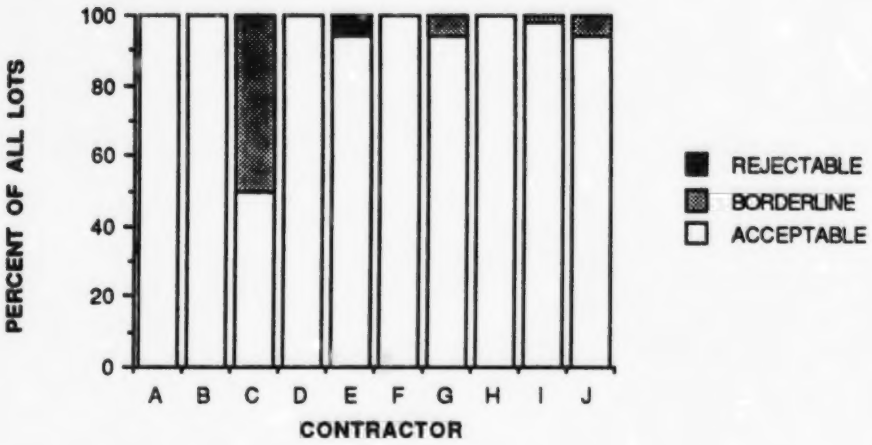


FIG. 3: CONTRACTOR PERFORMANCE



2.2 Material Quality

One hundred and seventy one samples, representing material from four manufacturers were tested in the Downsview laboratories. Eighty two percent of the samples met all test criteria with 18% failing one or more of the quality tests. Thirty one samples failed, resulting in a price reduction for the lots represented. All the failures were limited to three of the six quality criteria, cone penetration @ 50° C, flexibility and the ratio of toughness to maximum load. Figures 4 and 5 demonstrate the proportions of samples failing tests. The Price Adjustment Factors ranged from a low of 0.915 to a high of 0.998 with an average of 0.975. Figure 6 demonstrates the distribution of the four manufacturers products on Ministry work. Individual manufacturers statistics are contained in the appendix.

FIG. 4: THREE YEAR HISTORY OF QUALITY TESTS

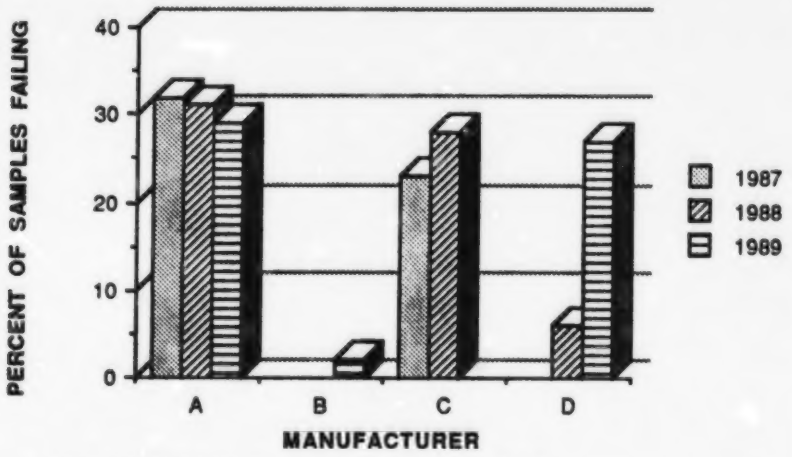


FIG. 5: TEST CRITERIA FAILED IN 1989

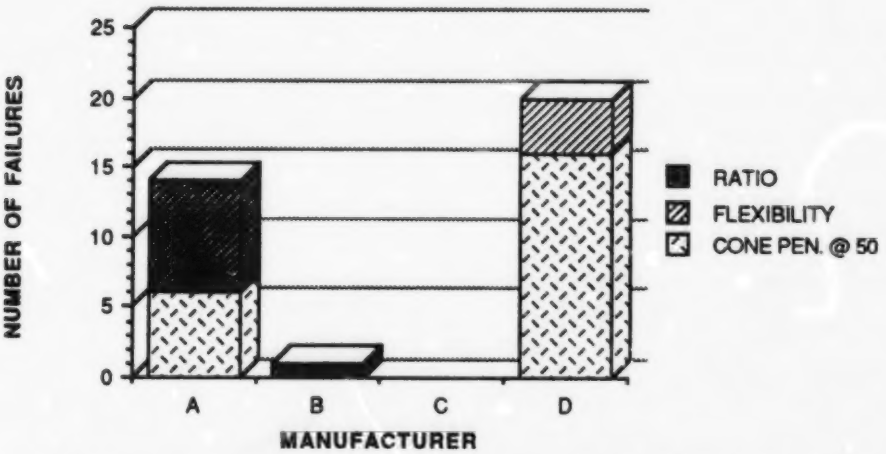
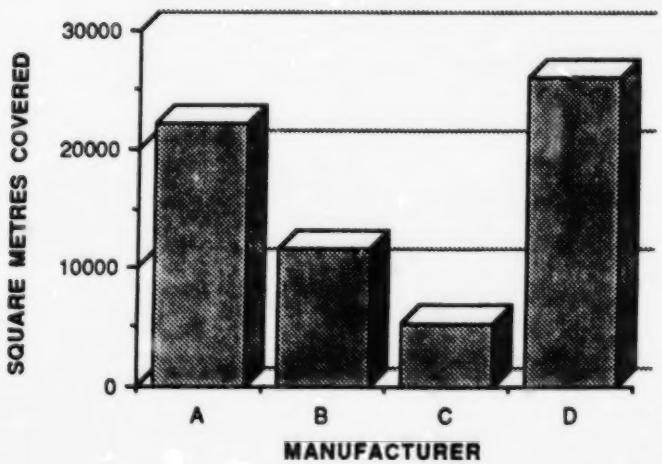


FIG. 6: MANUFACTURER'S SHARE OF AREA PLACED IN 1989



2.3 Material Mass Density

Although not a specification requirement, the mass density of each sample is determined in the laboratory. This mass density along with the other tests can be used to ascertain whether the sample is representative of the material as identified on the sample sheet. Since the various products have different mass densities, it is a useful tool to determine if a sample has been adulterated. In fact, the data strongly suggests that the one sample of material "B" that failed (first sample in three years) was adulterated.

From the mass density of each product, the quantity required to cover a given area may be determined. Table 2 presents the quantity of product required to cover a square metre with 5 mm of membrane based on the mean mass density determinations of the four products supplied to the Ministry in 1989.

TABLE 2 : MATERIAL REQUIRED PER SQUARE METRE OF BRIDGE DECK (5 mm thick)

PRODUCT	kg/m^2
BAKELITE 790-11	5.90
BE-RAM BEMALASTIC	7.80
HYDROTECH 6120 BD	5.80
PERMAQUIK 6100 BM	6.05

3 DISCUSSION

3.1 Material Thickness

When the statistical acceptance system involving price adjustment for thickness was first introduced, it was said by some contractors to be too restrictive or even unattainable.

The high level of compliance over the last two years with 96% and 97% of all lots respectively receiving full payment, demonstrates that contractors can work to the requirements of the acceptance system. The percent compliance has improved each year since the introduction of the ERS system in 1986 and will likely improve slightly in 1990.

The average lot thickness and standard deviation has remained static over the last three years and this suggests that these numbers are not likely to change much in the future. Any contractor attempting to reduce the quantity of material used (thinner membrane) will have to exercise a greater level of process control to avert the possibility of a price adjustment and this could well offset any potential savings.

3.2 Material Quality

When the quality component of the ERS was introduced in 1987 both waterproofing contractors and material manufacturers complained that if a sample fails a test, there can be controversy as to whether the product was non-compliant as supplied or whether it was adulterated or damaged by overheating in the hands of the contractor.

Some manufacturers have in fact claimed that "failure" of their samples was caused by the contractor, and the manufacturers have lobbied the Ministry to sample the material before on-site heating.

The Ministry has denied this request since it is the quality of the product in-place that is important.

In 1986 the Ministry changed the requirement for cone penetration at 50° C from a maximum of 200 down to a maximum of 160. Although the manufacturers have attempted to meet this new requirement and have for the most part been successful, it is the most frequently failed criteria. Failure of this test can sometimes be attributed to prolonged heating or overheating, in the contractor's kettle.

4 FIELD DOCUMENTATION

4.1 Material Thickness

Compilation of the Waterproofing Membrane Thickness Reports has improved over previous years but still about 50% of the reports are received with missing information and or incorrect computations. At least 25% of the reports received had the standard deviation of the thickness measurements incorrectly computed. Fortunately these errors seldom affected the payment adjustment factor.

Following are some of the most common errors, and they are the same as reported for the 1987 and 1988 work.

a. Stages, rather than whole bridge decks, are divided into lots. This results in the same lot number appearing twice for one bridge.

b. The area of a stage or lot is entered in the space for "Area of Deck".

c. The "brand" name of the membrane used is not recorded in the space for "Membrane".

d. Thickness results are recorded to one decimal place instead of to the closest whole millimetre. This results in an incorrect computation of the standard deviation and may also result in an incorrect mean value.

e. The standard deviation is incorrectly rounded off. It should be rounded to the closest 0.05. Incorrect rounding can make a significant difference in the determination of the payment adjustment factor.

f. The payment adjustment factor is entered as 0 or nil when it should be 1.0. This can lead to problems in determining payment for the lot when coupled with price adjustment for membrane quality.

4.2 Material Quality

Many samples were received without the Concrete Products Field Sample Sheet being adequately completed. Field staff should refer to the "Field Guide For Acceptance Of Bituminous Materials", to make sure that all required information is provided with the sample. This information is critical to our data base and to assure that price adjustment is applied to the correct lot should a sample fail the quality tests.

5 CONCLUSION

The introduction of end result specifications for the acceptance of bridge deck waterproofing has had, and is continuing to have, the desired impact of improving the quality of this important item of work.

Field testing in 1989 indicates 97% of all lots met thickness requirements.

Laboratory testing shows 82% of all samples tested complied for quality.

There are continuing problems with contract administration and documentation.

6 RECOMMENDATION

Quality Assurance staff should review the acceptance procedures for bridge deck waterproofing with the Project Supervisor, with particular emphasis on computations and documentation prior to commencement of all waterproofing work.

The Ministry should review the Membrane Quality Adjustment Points Table with a view to providing a greater incentive to both manufacturers and contractors to supply and install material meeting all quality criteria.

1989 WATERPROOFING SUMMARY

CONTRACTOR	AVE. THICK.	AVE. ST. DEV.	SQ. METRES	TOTAL NUMBER OF LOTS	NUMBER OF BORDERLINE LOTS	NUMBER OF REJECTABLE LOTS
D	4.30	0.50	255.0	1	0	0
B	5.50	0.55	271.0	1	0	0
C	4.70	0.88	735.0	2	1	0
H	4.66	0.67	2,823.6	9	0	0
F	5.13	0.86	3,445.0	9	0	0
E	5.07	0.64	3,697.2	16	0	1
J	4.83	0.58	3,894.3	18	1	0
A	4.83	0.57	10,022.3	47	0	0
G	4.92	0.68	17,657.7	35	2	0
I	4.90	0.61	22,250.3	51	1	0
		TOTAL	65,051.4	189	5	1

MANUFACTURER	AVE. THICK.	SQ. METRES	NUMBER OF SAMPLES TESTED	NUMBER OF SAMPLES FAILED	FAILED CONE PEN. @ 25 C	FAILED CONE PEN. @ 50 C	FAILED FLOW	FAILED FLEXIBILITY	FAILED TOUGHNESS	FAILED RATIO
C	4.70	5,289.6	15	0	0	0	0	0	0	0
B	4.83	11,571.1	47	1	0	0	0	0	0	1
A	4.96	22,084.1	45	13	0	6	0	0	0	8
D	4.91	26,106.6	64	17	0	16	0	4	0	0
	TOTAL	65,051.4	171	31	0	22	0	4	0	9